

**S/NUnknown**

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Applicant:	Michael J. O'Phelan et al.	Examiner:	Unknown
Serial No.:	Unknown	Group Art Unit:	Unknown
Filed:	Herewith	Docket No:	279.271US2
Title:	CAPACITOR HAVING A FEEDTHROUGH ASSEMBLY WITH A COUPLING MEMBER		

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**PRELIMINARY AMENDMENT**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Prior to taking up the above-identified application for examination, please enter the following amendments:

### **IN THE CLAIMS**

Please amend the claims as follows:

1-21. (Canceled)

22. (Original) A capacitor comprising:

a case having a feedthrough hole;

an capacitor stack within the case;

an elastic plug mounted within the feedthrough hole, the plug having an inner hole; and

a feedthrough conductor coupled to the capacitor and extending through the plug inner hole;

wherein the plug electrically insulates the feedthrough conductor from the case.

23. (Original) The capacitor of claim 22, wherein the elastic plug includes a flange confronting an inner surface of the case.

24. (Original) The capacitor of claim 22, wherein the capacitor comprises a flat capacitor.

25. (Original) The capacitor of claim 22, wherein the feedthrough conductor is directly attached to the capacitor stack.

26. (Original) The capacitor of claim 22, wherein the plug has one inner hole.

27. (Original) The feedthrough assembly of claim 22, wherein the plug includes a first flange located inside the case and a second flange located outside the case.

28. (Original) The feedthrough assembly of claim 22, wherein the feedthrough conductor comprises an aluminum coupling member having a first end extending from a first end of the

plug and having a second end extending from a second end of the plug and directly coupled to an active element of the flat capacitor.

29. (Original) An implantable medical device comprising:

one or more leads for sensing electrical signals of a patient or for applying electrical energy to the patient;

a monitoring circuit for monitoring heart activity of the patient through one or more of the leads; and

a therapy circuit for delivering electrical energy through one or more of the leads to a heart of the patient, wherein the therapy circuit includes one or more capacitors, each capacitor comprising:

a case having a feedthrough hole;

a capacitor stack located within the case;

a coupling member having a base surface directly attached to the capacitor stack, the coupling member having a mounting hole;

a feedthrough conductor having a portion extending into the mounting hole; and

a sealing member adjacent the feedthrough hole for sealing the feedthrough hole.

30. (Original) The implantable medical device of claim 29, wherein the coupling member comprises a base abutting a surface of the capacitor stack.

31. (Original) The implantable medical device of claim 30, wherein the capacitor stack includes two or more connection members, each connection member having an edge face, the surface of the capacitor stack comprises at least one of the edge connection member faces.

32. (Original) The implantable medical device of claim 29, wherein the sealing member comprises an elastic plug mounted within the feedthrough hole, the elastic plug having an inner hole, the feedthrough member mounted within the inner hole.

33. (Original) The implantable medical device of claim 32, wherein the elastic plug is interference fitted within the feedthrough hole.
34. (Original) A method for assembling a capacitor, the method comprising:
- crimping a feedthrough conductor to a coupling member;
  - attaching the coupling member to a capacitor stack of the flat capacitor;
  - inserting the capacitor stack into a capacitor case so that the feedthrough conductor passes through a feedthrough hole in the capacitor case; and
  - sealing the feedthrough hole.
35. (Original) The method of claim 34, wherein attaching the coupling member comprises butt-welding the coupling member to a flat connection surface of the active element.
36. (Original) The method of claim 34, wherein sealing the feedthrough hole comprises non-hermetically sealing the feedthrough hole by depositing an epoxy around the feedthrough hole.
37. (Original) The method of claim 34, wherein sealing the feedthrough hole comprises mounting an elastic insert within the feedthrough hole and inserting a feedthrough conductor through the elastic insert.
38. (Original) A method of sealing a feedthrough hole of a capacitor, the method comprising:
- mounting an elastic insert within the feedthrough hole; and
  - inserting a feedthrough conductor through the elastic insert.
39. (Original) The method of claim 38, wherein the elastic insert has a flange for holding the elastic insert within the feedthrough hole.

40. (Original) A method of manufacturing a capacitor having a capacitor case having a feedthrough hole, the method comprising:

mounting an elastic plug within the feedthrough hole so a first flange of the plug is on an inside of the case and so that a second flange of the elastic plug is on an outside of the case;

directly attaching a feedthrough conductor to a capacitor stack; and

inserting the feedthrough conductor through a hole in the elastic plug.

41. (Original) The method of claim 40, wherein the feedthrough conductor has an outer diameter approximately equal to or larger than an unstressed diameter of the hole in the elastic plug.

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**Conclusion**

Claims 1-21 have been canceled. Claims 22-41 are now pending. The Applicant respectfully requests that the preliminary amendment described herein be entered into the record prior to the examination and consideration of the above-identified application.

Respectfully Submitted,

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By their Representatives,

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Date of Deposit: May 14, 2004

This paper or fee is being deposited on the date indicated above with the United States Postal Service pursuant to 37 CFR 1.10, and is addressed to The Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

SCHWEGMAN ■ LUNDBERG ■ WOESSNER ■ KLUTH

**United States Patent Application**  
**COMBINED DECLARATION AND POWER OF ATTORNEY**

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **CAPACITOR HAVING A FEEDTHROUGH ASSEMBLY WITH A COUPLING MEMBER**.

The specification of which was filed on November 3, 2000 as application serial no. 09/706,579.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. § 1.56 (attached hereto). I also acknowledge my duty to disclose all information known to be material to patentability which became available between a filing date of a prior application and the national or PCT international filing date in the event this is a Continuation-In-Part application in accordance with 37 C.F.R. §1.63(e).

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

**No such claim for priority is being made at this time.**

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

**No such claim for priority is being made at this time.**

I hereby claim the benefit under 35 U.S.C. § 120 or 365(c) of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

**No such claim for priority is being made at this time.**

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Schwegman, Lundberg, Woessner & Kluth, P.A. to the contrary.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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X Additional inventors are being named on separately numbered sheets, attached hereto.



I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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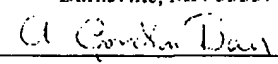
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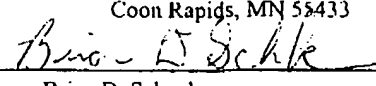
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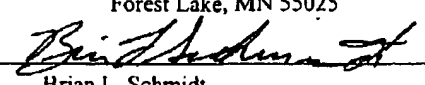
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§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
  - (i) Opposing an argument of unpatentability relied on by the Office, or
  - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

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- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

# **CAPACITOR HAVING A FEEDTHROUGH ASSEMBLY WITH A COUPLING MEMBER**

## **Cross-Reference to Related Applications**

5 This application is a division of Application Serial Number 09/706,579, filed on November 3, 2000, the specification of which is incorporated herein by reference.

This application is related to Application Serial Number 09/706,447, filed on November 3, 2000, now issued as U.S. Patent No. 6,699,265, which is incorporated herein by reference in its entirety.

10

## **Technical Field**

The present invention concerns implantable heart monitors, such as defibrillators and cardioverters, particularly structures and methods for capacitors in such devices.

15

## **Background**

20 Since the early 1980s, thousands of patients prone to irregular and sometimes life-threatening heart rhythms have had miniature heart monitors, particularly defibrillators and cardioverters, implanted in their bodies. These devices detect onset of abnormal heart rhythms and automatically apply corrective electrical therapy, specifically one or more bursts of electric current, to hearts. When the bursts of electric current are properly sized and timed, they restore normal heart function without human intervention, sparing patients considerable discomfort and often saving their lives.

25 The defibrillator or cardioverter includes a set of electrical leads, which extend from a sealed housing into the walls of a heart after implantation. Within the housing are a battery for supplying power, monitoring circuitry for detecting

abnormal heart rhythms, and a capacitor for delivering bursts of electric current through the leads to the heart.

The capacitor can take the form of a flat aluminum electrolytic capacitor.

Flat capacitors include a stack of flat capacitor elements, with each element including one or more separators between two sheets of aluminum foil. The

5 capacitor elements, each of which has an individual capacitance (or energy-storage capacity) proportional to the surface area of the aluminum foil, are connected together to provide a total capacitance. The stack of capacitor elements is housed within an aluminum capacitor case which is filled with electrolyte.

The capacitor includes one or more metal wires, known as feedthroughs,  
10 which connect the capacitor elements to defibrillator or cardioverter circuitry located outside the case. A feedthrough reaches the outside of the case through a hole in the case called a feedthrough hole. After the capacitor elements are assembled within the capacitor case and the feedthrough is inserted through the feedthrough hole, manufacturers insulate the feedthrough from the case and seal the feedthrough hole.  
15 This involves, for instance, assembling an insulating sleeve, a nut, a gasket and/or other hardware around the feedthrough wire.

Thus, assembling the feedthrough, insulating the feedthrough, and sealing the feedthrough is a complex, time-consuming process.

## 20 Summary

To address these and other needs, the inventors have devised new capacitor structures and methods. An exemplary capacitor includes a case containing a capacitor stack. A coupling member having a base surface is directly attached to the capacitor stack. A feedthrough conductor has a portion which extends through a  
25 feedthrough hole in the case and into a mounting hole in the coupling member. The capacitor includes a sealing member adjacent the feedthrough hole and the feedthrough conductor for sealing the feedthrough hole.

One option provides an exemplary feedthrough assembly which includes a plug having a hole and a feedthrough conductor mounted within the hole. The feedthrough conductor has a diameter approximately equal to or larger than the plug hole diameter, thus sealing the feedthrough hole without requiring any epoxy or excess hardware.

- 5           Among other advantages, the relatively uncomplicated feedthrough structure of the exemplary capacitor provides for easier manufacturing and more reliable capacitors. Other facets of the invention include various implantable medical devices, such as pacemakers, defibrillators, and cardioverters, incorporating one or more features of the novel capacitors.

10

#### **Brief Description of Drawings**

FIG. 1 is an isometric view of a flat capacitor in accord with one embodiment of the present invention.

FIG. 2 is an exploded isometric view of the flat capacitor of FIG. 1.

- 15   FIG. 3 is another exploded isometric view of the flat capacitor of FIG. 1.

FIG. 4 is a cross-sectional view of the feedthrough assembly of FIG. 1.

FIG. 5A is an isometric view of the exemplary feedthrough assembly of FIG. 1.

FIG. 5B is a side view of the exemplary feedthrough assembly of FIG. 1

- FIG. 6 is an isometric view of an exemplary coupling member in accord with one  
20   embodiment of the present invention.

FIG. 7 is an isometric view of another exemplary coupling member in accord with one embodiment of the present invention.

FIG. 8A is an isometric view of another exemplary coupling member in accord with one embodiment of the present invention.

- 25   FIG. 8B is an isometric view of another exemplary coupling member in accord with one embodiment of the present invention.

FIG. 9 is a side view of the feedthrough assembly of FIG. 1.

FIG. 10 is an exploded isometric view of a flat capacitor according to one embodiment of the present invention.

FIG. 11 is a cross-sectional view of the feedthrough assembly of FIG. 10.

FIG. 12 is a cross-sectional side view showing a feedthrough plug according to one embodiment.

- 5 FIG. 13 is a schematic view of an exemplary implantable medical device incorporating a capacitor according to the present invention.

### **Detailed Description**

The following detailed description, which references and incorporates the  
10 figures, describes and illustrates one or more specific embodiments of the invention. These embodiments, offered not to limit but only to exemplify and teach the invention, are shown and described in sufficient detail to enable those skilled in the art to practice the invention. Thus, where appropriate to avoid obscuring the invention, the description may omit certain information known to those of skill in  
15 the art.

Figure 1 shows a flat capacitor 100 in accord with one embodiment of the present invention. Capacitor 100 includes a case 101, a feedthrough assembly 103, a terminal 104, and a sealing member 105. In the exemplary embodiment, case 101 is a D-shaped container manufactured from a conductive material, such as aluminum.  
20 In other embodiments, case 101 is rectangular, circular, oval, or other desirable symmetrical or asymmetrical shape. Also, in some embodiments, case 101 is manufactured from a nonconductive material, such as a ceramic or a plastic.

Case 101 includes a feedthrough hole 107 which is drilled, molded, or punched in a portion of a wall of case 101. Feedthrough hole 107 is in part defined  
25 by an edge 107a which outlines the feedthrough hole within case 101. Feedthrough hole 107 provides a passage for connecting feedthrough assembly 103 to circuitry

outside of case 101. In some embodiments, case 101 includes two or more feedthrough holes for providing a second or third feedthrough assembly.

Feedthrough assembly 103 and terminal 104 connect capacitor elements to outside circuitry. In the exemplary embodiment, feedthrough assembly 103 extends through feedthrough hole 107 and is insulated from case 101. Terminal 104 is  
5 directly connected to case 101. Alternatively, in some embodiments, the capacitor incorporates other connection methods, depending on other design factors. In various embodiments, two or more insulated feedthrough assemblies are employed.

In the exemplary embodiment, sealing member 105, such as an epoxy, is deposited around feedthrough hole 107 and feedthrough assembly 103 to insulate  
10 feedthrough assembly 103 from case 101 and to seal an electrolyte within the case. An exemplary epoxy is a two-part epoxy manufactured by Dexter Hysol. This includes a casting resin compound (manufacturer No. EE 4183), a casting compound (manufacturer No. EE 4215), and a hardener (manufacturer No. HD 3404). The exemplary two-part epoxy is mixed in a ratio of hardener = 0.055 \* casting resin.  
15 The mixture is cured at 0.5 hours at 60 degrees Celsius or 1.5 hours at room temperature. Another exemplary epoxy is a UV cure epoxy such as manufactured by Dymax, Inc., which can be cured using an Acticure (manufactured by GenTec) ultraviolet curing system at 7 W/cm<sup>2</sup> at a distance of 0.25" for approximately 10 seconds.

20 In one embodiment, the sealing member provides a non-hermetic seal. In one embodiment, the sealing member includes an elastic plug which will be discussed in further detail below.

Figures 2 and 3 show exploded views of exemplary capacitor 100. Capacitor 100 includes a capacitor stack 202 mounted within an internal cavity 212. The  
25 exemplary capacitor stack 202 includes a plurality of capacitor modules or elements 205a, 205b, 205c, . . . , 205n. Each of elements 205a-205n includes a cathode, an anode, and a separator between the cathode and the anode.

Each anode includes one or more anode members in a stack. These anodes and cathodes are foil structures and can be made from aluminum, tantalum, hafnium, niobium, titanium, zirconium, and combinations of these metals. A major surface of each anode foil is roughened to increase its effective surface area. This increases the capacitive effect of the foil with no relative increase in volume.

- 5 However, none of the embodiments are limited to any particular foil composition or class of foil compositions.

The separators include one or more electrolyte impregnated separators between each anode and each cathode. In the exemplary embodiment, each separator consists of two kraft papers impregnated with an electrolyte. The  
10 electrolyte can be any suitable electrolyte for an electrolytic capacitor, such as an ethylene-glycol base combined with polyphosphates, ammonium pentaborate, and/or an adipic acid solute. Other embodiments incorporate different numbers and arrangements of anodes, cathodes, and separators.

In the exemplary embodiment, each cathode of capacitor stack 202 is  
15 connected to the other cathodes and to conductive case 101. Terminal 104 is attached to case 101 to provide a cathode connection to outside circuitry. In some embodiments, the cathode is coupled to a feedthrough conductor extending through a feedthrough hole.

In the exemplary embodiment, each anode is connected to the other anodes  
20 of the capacitor. Attached to the anode of each capacitor element 205a-205n is a conductive tab or connection member 201. In one embodiment, each connection member 201 includes an edge face 215 which is substantially perpendicular to the major surface of the anodes. Edge face 215 provides a conductive surface for connecting each capacitor element 205a-205n to feedthrough assembly 103. The  
25 anode connection members 201 are welded or crimped together and are coupled to feedthrough assembly 103 for electrically connecting the anode to circuitry outside the case. In some embodiments, the cathode is coupled to a feedthrough assembly



and the anode is connected to the case. In other embodiments, both the anode and the cathode are connected to feedthroughs.

In one embodiment, connection members 201 are edge-welded to each other as discussed in U.S. Patent Application No. 09/706,518, filed November 3, 2000, now issued as U.S. Patent No. 6,687,118, which is incorporated herein by reference  
5 in its entirety. Edge-welding the connection members provides a flat connection surface 216, which includes one or more edge faces 215 of connection members 201. In some embodiments, connection members 201 are crimped, soldered, and/or connected by an electrically conductive adhesive.

In the exemplary embodiment, feedthrough assembly 103 includes two  
10 members, a feedthrough wire or conductor 203 and a coupling member 204. Coupling member 204 is attached to capacitor stack 202 at connection surface 216, and feedthrough conductor 203 is attached to coupling member 204. In the exemplary embodiment, coupling member 204 partially extends through feedthrough hole 107.

15 Feedthrough conductor 203 is a conductive member which can include material such as nickel, gold plated nickel, platinum, aluminum, or other conductive metal. Feedthrough conductor 203 has a proximal end portion 217 attached to coupling member 204 and a distal end portion 218 for attaching to circuitry outside the case, such as defibrillator or cardioverter circuitry. In the exemplary  
20 embodiment, feedthrough conductor 203 has a diameter of approximately 0.016" (0.4064 mm). However, other embodiments have feedthrough conductors of different diameters and/or non-circular cross-sections.

Figure 4 shows a cross-sectional side view of details of one embodiment of feedthrough assembly 103 and its connection to connection members 201. As  
25 discussed above, in the exemplary embodiment, the edge faces 215 of each connection member 201 form a substantially flat connection surface 216. In the

exemplary embodiment, coupling member 204 is directly attached to connection members 201 at surface 216.

In the exemplary embodiment, coupling member 204 is a high-purity aluminum member which is able to withstand the high voltages generated within the capacitor case. In other embodiments it is made from another conductive material compatible with the capacitor stack. Coupling member 204 includes a base 404 and a holding tube 407. On one side of base 404 is a planar surface 405 for attaching to the planar surface 216 presented by edge-welded connection members 201.

Figure 6 shows additional details of exemplary base 404. In the exemplary embodiment, base 404 is substantially rectangular having a pair of opposing rounded or curved ends 602 and 604.

Referring again to Figure 4, in the exemplary embodiment, coupling member 204 is situated so that surface 405 abuts connection member surface 216. Coupling member 204 is laser welded using a butt-weld to surface 216 of connection members 201. Alternatively, coupling member 204 is attached using other means. Butt-welding coupling member 204 directly to connection members 201 provides an optimal electrical connection between capacitor stack 202 and the feedthrough assembly. Moreover, it also provides for a compact capacitor since very little, if any, space is wasted between capacitor stack 202 and feedthrough assembly 103. Also, since coupling member 204 is directly attached to capacitor stack 202, it helps support feedthrough conductor 203 while a sealing member 105, such as an epoxy, is applied to the feedthrough hole area.

Holding tube 407 is located on the opposing side of base 404 from surface 405. Tube 407 is a cylindrical member having an outer diameter dimensioned to fit within feedthrough hole 107. Tube 407 has a mounting section such as mounting hole 401 defined in part by an inner surface 402 of holding tube 406 which is generally perpendicular to base surface 405. Hole 401 is located down an axial portion of the tube.

Mounting section or hole 401 is for receiving proximal end portion 217 of feedthrough conductor 203. The surface of feedthrough conductor 203 contacts inner surface 402. In the exemplary embodiment, hole 401 is approximately 0.016" (0.4064 mm) in diameter. Alternatively, its diameter can conform with the size of conductor 203 so that feedthrough conductor 203 can matably fit within the hole.

- 5 In the exemplary embodiment, coupling member 204 has a height 204h of approximately 0.085" (2.519 mm). Other embodiments range from 0.050" to 0.100" or higher. Some embodiments provide a height of greater than 0.100".

Figures 5A and 5B show an exemplary attachment of feedthrough conductor 203 to coupling member 204. In the exemplary embodiment, feedthrough conductor 203 and coupling member 204 are connected at a crimp 502. Alternatively, they are  
10 welded, soldered, glued or interference fit together, as will be discussed below. Exemplary crimp 502 compresses inner surface 402 (see Figure 4) of tube 407 into mechanical and electrical connection with the surface of portions of feedthrough conductor 203. In the exemplary embodiment, a double crimp is employed. In  
15 some embodiments, a single crimp, double crimp, triple crimp or more are used.

In the exemplary embodiment, inner surface 402 of coupling member 204 is a curved surface defining an annular connection member. Crimp 502 compresses and deforms opposing surfaces of annular inner surface 402 to contact conductor 203. In the exemplary embodiment, the opposing surfaces of inner surface 402 are  
20 separated by a first distance prior to being crimped and separated by a second distance, smaller than the first distance, after being crimped.

Figure 7 shows another exemplary coupling member 700. Member 700 includes a base 701 and a holding tube 702. Base 701 is a circular-shaped base. In the exemplary embodiment, base 701 has a diameter of approximately 0.050" (1.27  
25 mm). In one embodiment (not shown), the base is square shaped.

Figure 8A shows another exemplary coupling member 800. Member 800 does not include a base. In the exemplary embodiment, hole 401 runs completely

through holding tube 802. In the exemplary embodiment, one end of tube 802 has a connection surface and is attached to surface 216 of connection members 201. A second end of tube 802 receives feedthrough conductor 203.

Figure 8B shows another exemplary coupling member 850. Member 850 does not include a base. In the exemplary embodiment, hole 401 runs only partially  
5 through a holding tube 852. In the exemplary embodiment, one end of member 850 has a connection surface and is attached to surface 216 of connection members 201. An end of tube 802 receives feedthrough conductor 203.

Figure 9 shows a side view of feedthrough assembly 103 in which feedthrough conductor 203 is coupled to coupling member 204 at one or more arc  
10 percussion welding areas, such as areas 982a and 982b. An exemplary arc percussion welding machine is manufactured by Morrow Tech Industries of Broomfield, Colorado. In this embodiment, the conductor 203 and coupling members are not crimped together. However, some embodiments include both welding and crimping.

Figure 10 shows an exploded view of capacitor 100 having a sealing member  
15 such as a plug 106 according to one embodiment of the present invention. Plug 106 is insertable into feedthrough hole 107 of case 101. In one embodiment, plug 106 has an outer diameter which is larger than the diameter of feedthrough hole 107, and the manufacturer inserts it within hole 107 in an interference fit. When plug 106 is  
20 located within feedthrough hole 107, the plug seals feedthrough hole 107 and electrically insulates feedthrough assembly 103 from case 101. In some embodiments plug 106 includes one or more flanges, which will be discussed below.

Figure 11 shows a cross-sectional view of plug 106 assembled with capacitor  
case 101. The present example show coupling member 204 attached to capacitor  
25 stack 202. However, in other embodiments plug 106 can also be used in capacitors having other types of feedthrough assemblies. In one embodiment, plug 106 electrically insulates case 101 from coupling member 204. Coupling member 204

has a first end 1115 located in the interior of case 101 and coupled to capacitor stack 202. Coupling member 204 also includes a second end 1111 located exterior to case 101 for connecting to circuitry, such as defibrillator, or other implantable medical device circuitry. In one embodiment, coupling member 204 has a feedthrough terminal attached thereto.

5           In this embodiment, plug 106 is a double-flanged plug. Plug 106 includes a first flange 108. First flange 108 includes a first surface 108a which faces the inner surface of case 101. When the capacitor begins to become pressurized, pressure against a second surface 108b forces first surface 108a against the case. Thus, flange 108 creates a seal against the inner surface of case 101.

10           In this embodiment, plug 106 includes a second flange 109. Flange 109 includes a surface which faces the outer surface of case 101.

          Plug 106 also includes a plug portion 110 which is located between and defined by first flange 108 and second flange 109. Portion 110 has a smaller diameter than either flange 108 and/or 109. Case edge 107a confronts plug 106 at  
15           portion 110. In this embodiment, portion 110 has a normal, unstressed outer diameter approximately equal to the diameter of feedthrough hole 107. In some embodiments, the unstressed outer diameter is larger than the diameter of feedthrough hole 107. In some embodiments, the unstressed outer diameter is smaller than hole 107. As one example, in this embodiment flange 108 has a  
20           diameter of approximately 0.080 inches and portion 110 has a diameter of approximately 0.060 inches.

          Plug 106 also includes a central passage or hole 1102. In one embodiment, hole 1102 is axially located through the center of plug 106 and has an unstressed diameter 1102d which is smaller than or equal to a diameter 103d of a portion of  
25           feedthrough member 103 which is mounted within hole 1102. In various embodiments, diameter 1102d may range from approximately 0.015 inches to approximately 0.033 inches. In other embodiments, diameter 1102d is smaller than

0.015 inches. In some embodiments it is greater than 0.033 inches. Other  
embodiments vary the hole size depending on the size of the feedthrough conductor  
used. In some embodiments, when a feedthrough member such as coupling member  
204 is inserted through hole 1102, an interference fit seal is developed between the  
feedthrough member and the plug. In other embodiments, hydrogen gas can escape  
5 along the feedthrough member/plug 106 border.

In one embodiment, plug 106 is made from a compressible, elastic material  
such as rubber, plastic, thermoplastic, or other elastic or elastomeric material. In  
one embodiment, when plug 106 is mounted within feedthrough hole 107 and  
feedthrough member 103 is mounted within hole 1102, plug portion 110 is  
10 compressed between assembly 103 and edge 107a of feedthrough hole 107 and the  
plug exerts a radial force on edge 107a of the feedthrough hole. This forces or  
compresses plug 106 into an interference or compression fit between feedthrough  
hole edge 107a and member 204, thus helping to seal electrolyte solution within  
case 101. In other embodiments, the diameter of portion 110 is smaller than hole  
15 107 and an interference fit between feedthrough hole edge 107a and member 204 is  
not created.

In one embodiment, as noted above, flange 108 provides a sealing means for  
helping seal electrolyte within the case. Accordingly, in some embodiments, when  
the diameter of portion 110 is smaller than hole 107 and an interference fit between  
20 feedthrough hole edge 107a and member 204 is not created, only flange 108  
provides a sealing means between case 101 and plug 106. Advantageously, the seal  
or seals are formed automatically. Thus, in one embodiment, assembling and  
tightening a screw or other extraneous hardware is not required to seal the capacitor.

In one embodiment, second flange 109 provides support for mounting plug  
25 106 within hole 107. For instance, when plug 106 is mounted in hole 107, flanges  
108 and 109 each help hold plug 106 in place once it is mounted, but before the

coupling member 204 is inserted through hole 1102. This aides the manufacturing process.

In one embodiment second flange 109 includes a tapered section wherein an outer portion 109a of flange 109 has a smaller diameter than an inner portion 109b. The tapered shape of flange 109 aids in inserting plug 106 into hole 107. Some  
5   embodiments omit the tapered shape and flange 109 has a uniform outer diameter. Other embodiments provide a tapered shape for first flange 108. Other embodiments provide tapered sections on both flanges.

In this embodiment, flange 108 has a larger diameter than flange 109. In some embodiments, the two flanges have substantially equal diameters. In further  
10   embodiments, flange 109 has a larger diameter than flange 108.

Some embodiments omit either or both of flanges 108 and 109. For instance, in some embodiments plug 106 has a generally cylindrical shape. In other embodiments, plug 106 has an hour-glass shape or other shape which closely fits within feedthrough hole 107. In some embodiments, plug 106 is a mass of elastic  
15   material with a dimension approximately equal to or larger than the width of feedthrough hole 107.

In one embodiment, plug 106 seals the electrolyte within capacitor case 101, but it does not provide a hermetic seal. Hydrogen is created during consumption of water from the electrolyte and continues to be formed throughout the life of the  
20   capacitor. This can cause a hermetically sealed capacitor case to bulge outward from the hydrogen gas production within, thus risking long-term device reliability due to shorting.

Accordingly, in one embodiment plug 106 permits out-gassing of hydrogen gas, thus alleviating any problems. For instance, in one embodiment, flange 108  
25   creates a seal to the inner wall of the case 101. A pathway for the gas to escape is then present along the border between coupling member 204 and plug 106.

Figure 12 shows a cross-sectional side view of a plug 120 according to one embodiment. Plug 120 includes one or more features of plug 106 and discussion of unnecessary details will be omitted. Plug 120 includes a first flange 128, a second flange 129, and a portion 130 between the two flanges 128 and 129. In one embodiment, plug 130 includes a hole 132. Hole 132 has a sealing section such as a narrow section 132b, which is located between two nominal diameter sections 132a and 132b. Other embodiments omit section 132b or move it to either end, thereby omitting sections 132a or 132b.

In one embodiment, narrow section 132b provides an O-ring type interference fit for a feedthrough member such as coupling member 204. In this embodiment, narrow section 132b is generally located within second flange 129. Other embodiments locate the narrow section within central portion 130. Other embodiments locate the narrow section within first flange 128. By way of example, in one embodiment, the nominal diameters of sections 132a and 132c is approximately 0.032 inches, and the diameter of narrow section 132b is 0.026 inches.

Referring again to Figure 10, one method of assembling a capacitor having a plug 106 is as follows. Plug 106 is inserted into feedthrough hole 107 of case 101. In one embodiment, plug 106 includes a double-flange construction which helps hold the plug in place once it is mounted. Feedthrough assembly 103 is attached to capacitor stack 202 and inserted through inner hole 1102 of plug 106 while capacitor stack 202 is placed within the cavity of case 101. An interference fit between plug 106 and feedthrough 103 and between case 101 and plug 106 are created. Thus, a seal is formed between the interior of case 101 and the exterior of case 101.

#### Exemplary Embodiment of Implantable Defibrillator

Figure 13 shows one of the many applications for capacitors incorporating one or more teachings of the present invention: a generic implantable heart monitor



1300. As used herein, implantable heart monitor includes any implantable device for providing therapeutic stimulus to a heart muscle. Thus, for example, the term includes pacemakers, defibrillators, cardioverters, congestive heart failure devices, and combination and permutations thereof.

Heart monitor 1300 includes a lead system 1303, which after implantation  
5 electrically contact strategic portions of a patient's heart. Shown schematically are portions of monitor 1300 including a monitoring circuit 1302 for monitoring heart activity through one or more of the leads of lead system 1303, and a therapy circuit 1301 for delivering electrical energy through one or more of the leads to a heart. Monitor 1300 also includes an energy storage component, which includes a battery  
10 1304 and incorporates at least one capacitor 1305 having one or more of the features of the exemplary capacitors described above.

In addition to implantable heart monitor and other cardiac rhythm management devices, one or more teachings of the present invention can be incorporated into photographic flash equipment or other devices using flat or  
15 cylindrical capacitors. Indeed, these teachings of the invention are pertinent to any application where high-energy, high-voltage, or space-efficient capacitors are desirable.

#### Conclusion

20 In furtherance of the art, the inventors have devised a capacitor which includes, in an exemplary embodiment, a coupling member attached to a capacitor stack of the capacitor, a feedthrough conductor attached to the coupling member and extending through the feedthrough hole of the capacitor, and means for sealing the feedthrough hole. One embodiment provides a feedthrough assembly which  
25 includes a plug having a hole and a feedthrough conductor mounted within the hole. The feedthrough conductor has a diameter approximately equal to or larger than the plug hole diameter, thus sealing the feedthrough hole without requiring any excess

hardware. Among other advantages, the relatively uncomplicated feedthrough structure of the exemplary embodiments provides for easier manufacturing and more reliable capacitors.

The embodiments described above are intended only to illustrate and teach one or more ways of practicing or implementing the present invention, not to restrict  
5 its breadth or scope. The actual scope of the invention, which embraces all ways of practicing or implementing the teachings of the invention, is defined only by the following claims and their equivalents.

What is claimed is:

1. A capacitor comprising:
  - a case having a feedthrough hole;
  - a capacitor stack located within the case;
  - a coupling member having a base surface directly attached to the capacitor stack and a portion at least partially extending through the feedthrough hole, the coupling member having a mounting section;
  - a feedthrough conductor having a portion coupled to the mounting section;and
  - a sealing member adjacent the feedthrough hole for sealing the feedthrough hole.
2. The capacitor of claim 1, wherein the feedthrough hole is non-hermetically sealed.
3. The capacitor of claim 1, wherein the base surface is butt-welded to a flat connection surface of the capacitor stack.
4. The capacitor of claim 3, wherein the base surface comprises a planar surface.
5. The capacitor of claim 1, wherein the mounting section comprises a hole and the feedthrough conductor is crimped within the hole.
6. The capacitor of claim 1, wherein the mounting section comprises a hole and the feedthrough conductor is arc welded to the coupling member.

7. The capacitor of claim 1, wherein the coupling member comprises an aluminum material and the feedthrough conductor comprises a non-aluminum material.
8. The capacitor of claim 7, wherein the coupling member further comprises a holding tube having a passage that mates with the feedthrough conductor.
9. The capacitor of claim 8, wherein the feedthrough conductor has a diameter approximately the same as a diameter of the holding tube passage, the feedthrough conductor attached within the holding tube passage.
10. The capacitor of claim 1, wherein the sealing member comprises an epoxy deposited around the feedthrough hole.
11. The capacitor of claim 1, wherein the sealing member comprises an elastic plug.
12. A feedthrough assembly for a capacitor, the feedthrough assembly comprising:
  - a coupling member for attaching to a capacitor stack of the capacitor, the coupling member having a mounting hole; and
  - a feedthrough conductor having a width dimensioned to fit within the mounting hole of the coupling member.
13. The feedthrough assembly of claim 12, wherein the coupling member includes a planar base surface for attaching to the capacitor stack of the flat capacitor.

14. The feedthrough assembly of claim 12, wherein the feedthrough conductor is welded within the mounting hole.
15. The feedthrough assembly of claim 12, wherein the feedthrough conductor is crimped within the mounting hole.
16. A capacitor comprising:  
a case including a portion having a feedthrough hole;  
a capacitor element having one or more conductive surfaces;  
a feedthrough conductor; and  
a coupling member having a first surface contacting one or more of the conductive surfaces of the capacitor element and second and third opposing surfaces contacting the feedthrough conductor and extending through the feedthrough hole.
17. The capacitor of claim 16, wherein the first surface is substantially perpendicular to the second and third opposing surfaces.
18. The capacitor of claim 16, further comprising a weld joining at least a portion of the first surface of the coupling member to the one or more conductive surfaces.
19. The capacitor of claim 16, wherein the second and third opposing surfaces are curved.
20. The capacitor of claim 16, wherein the coupling member has a portion outside the case and a portion inside the case.

21. The capacitor of claim 16, wherein the coupling member is electrically conductive.
22. A capacitor comprising:  
a case having a feedthrough hole;  
an capacitor stack within the case;  
an elastic plug mounted within the feedthrough hole, the plug having an inner hole; and  
a feedthrough conductor coupled to the capacitor and extending through the plug inner hole;  
wherein the plug electrically insulates the feedthrough conductor from the case.
23. The capacitor of claim 22, wherein the elastic plug includes a flange confronting an inner surface of the case.
24. The capacitor of claim 22, wherein the capacitor comprises a flat capacitor.
25. The capacitor of claim 22, wherein the feedthrough conductor is directly attached to the capacitor stack.
26. The capacitor of claim 22, wherein the plug has one inner hole.
27. The feedthrough assembly of claim 22, wherein the plug includes a first flange located inside the case and a second flange located outside the case.
28. The feedthrough assembly of claim 22, wherein the feedthrough conductor comprises an aluminum coupling member having a first end extending from a first

end of the plug and having a second end extending from a second end of the plug and directly coupled to an active element of the flat capacitor.

29. An implantable medical device comprising:
- one or more leads for sensing electrical signals of a patient or for applying electrical energy to the patient;
  - a monitoring circuit for monitoring heart activity of the patient through one or more of the leads; and
  - a therapy circuit for delivering electrical energy through one or more of the leads to a heart of the patient, wherein the therapy circuit includes one or more capacitors, each capacitor comprising:
    - a case having a feedthrough hole;
    - a capacitor stack located within the case;
    - a coupling member having a base surface directly attached to the capacitor stack, the coupling member having a mounting hole;
    - a feedthrough conductor having a portion extending into the mounting hole; and
    - a sealing member adjacent the feedthrough hole for sealing the feedthrough hole.

30. The implantable medical device of claim 29, wherein the coupling member comprises a base abutting a surface of the capacitor stack.

31. The implantable medical device of claim 30, wherein the capacitor stack includes two or more connection members, each connection member having an edge face, the surface of the capacitor stack comprises at least one of the edge connection member faces.

32. The implantable medical device of claim 29, wherein the sealing member comprises an elastic plug mounted within the feedthrough hole, the elastic plug having an inner hole, the feedthrough member mounted within the inner hole.
33. The implantable medical device of claim 32, wherein the elastic plug is interference fitted within the feedthrough hole.
34. A method for assembling a capacitor, the method comprising:  
crimping a feedthrough conductor to a coupling member;  
attaching the coupling member to a capacitor stack of the flat capacitor;  
inserting the capacitor stack into a capacitor case so that the feedthrough conductor passes through a feedthrough hole in the capacitor case; and  
sealing the feedthrough hole.
35. The method of claim 34, wherein attaching the coupling member comprises butt-welding the coupling member to a flat connection surface of the active element.
36. The method of claim 34, wherein sealing the feedthrough hole comprises non-hermetically sealing the feedthrough hole by depositing an epoxy around the feedthrough hole.
37. The method of claim 34, wherein sealing the feedthrough hole comprises mounting an elastic insert within the feedthrough hole and inserting a feedthrough conductor through the elastic insert.
38. A method of sealing a feedthrough hole of a capacitor, the method comprising:  
mounting an elastic insert within the feedthrough hole; and



inserting a feedthrough conductor through the elastic insert.

39. The method of claim 38, wherein the elastic insert has a flange for holding the elastic insert within the feedthrough hole.

40. A method of manufacturing a capacitor having a capacitor case having a feedthrough hole, the method comprising:

mounting an elastic plug within the feedthrough hole so a first flange of the plug is on an inside of the case and so that a second flange of the elastic plug is on an outside of the case;

directly attaching a feedthrough conductor to a capacitor stack; and

inserting the feedthrough conductor through a hole in the elastic plug.

41. The method of claim 40, wherein the feedthrough conductor has an outer diameter approximately equal to or larger than an unstressed diameter of the hole in the elastic plug.

## **CAPACITOR HAVING A FEEDTHROUGH ASSEMBLY WITH A COUPLING MEMBER**

### **Abstract of the Disclosure**

5           A flat capacitor includes a case having a feedthrough hole, a capacitor stack  
located within the case, a coupling member having a base surface directly attached  
to the capacitor stack and having a portion extending through the feedthrough hole,  
the coupling member having a mounting hole, a feedthrough conductor having a  
portion mounted within the mounting hole, and a sealing member adjacent the  
10 feedthrough hole and the feedthrough conductor for sealing the feedthrough hole.  
Other aspects of the invention include various implantable medical devices, such as  
pacemakers, defibrillators, and cardioverters, incorporating one or more features of  
the exemplary feedthrough assembly.

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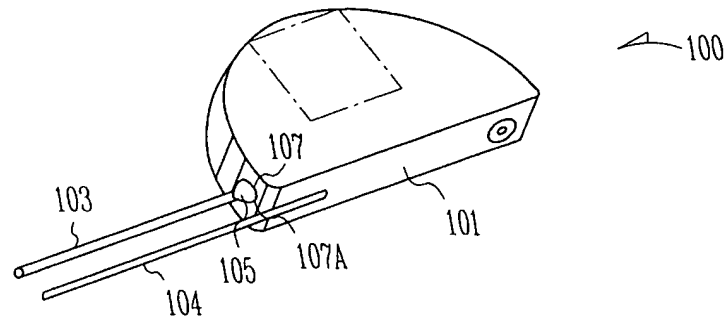


Fig.1

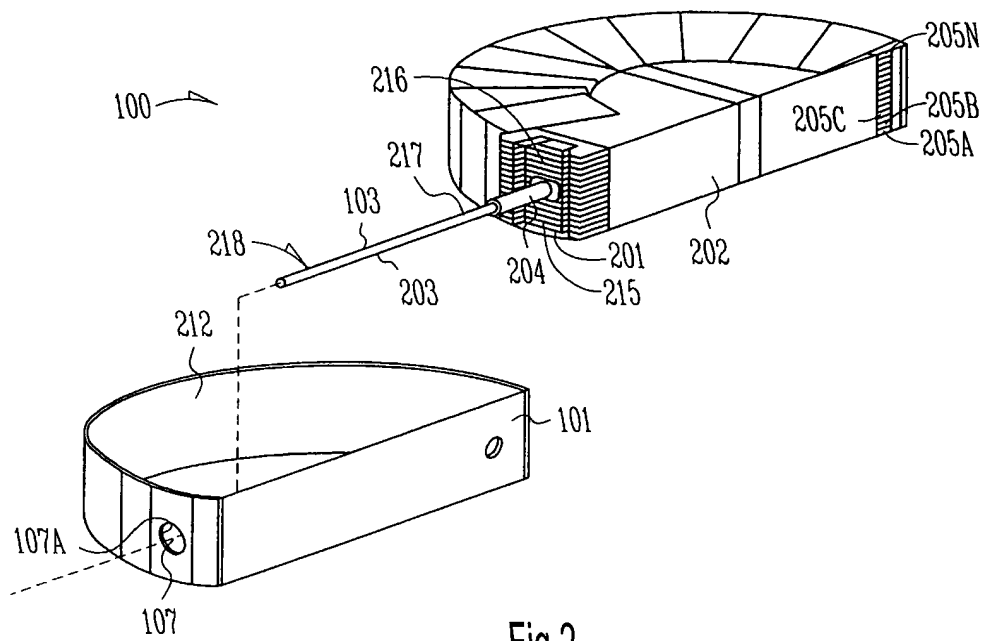


Fig.2

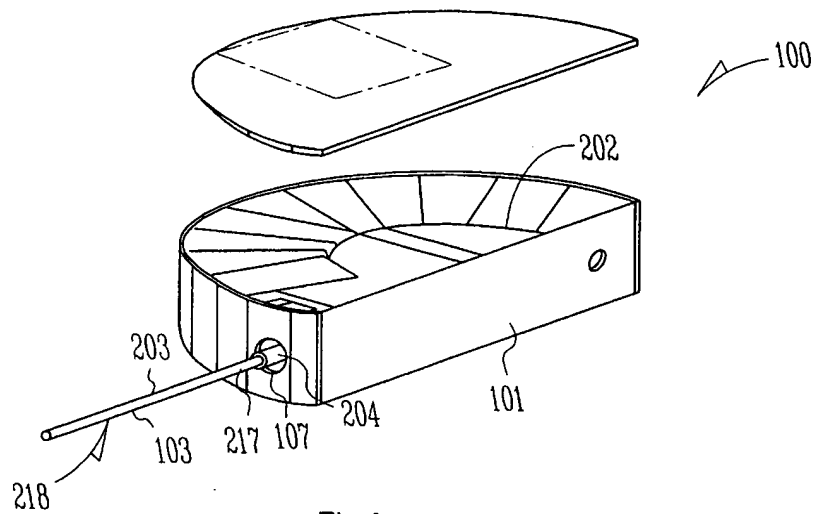


Fig.3

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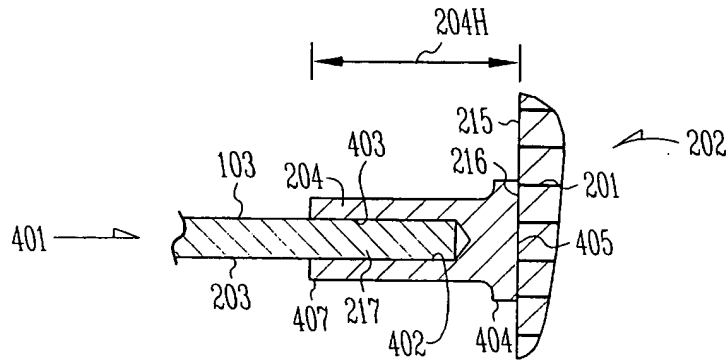


Fig.4

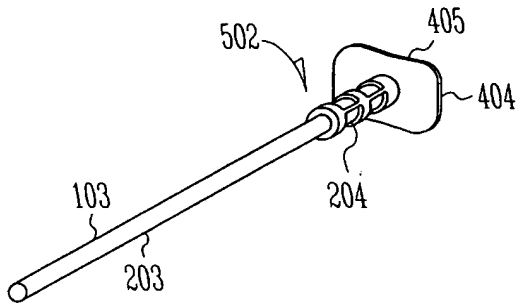


Fig.5A

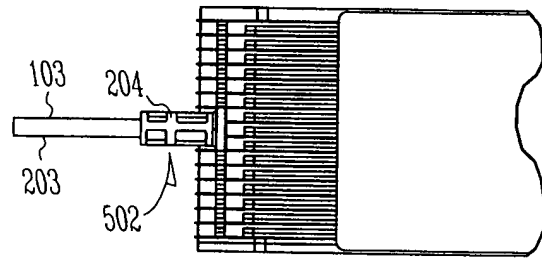


Fig.5B

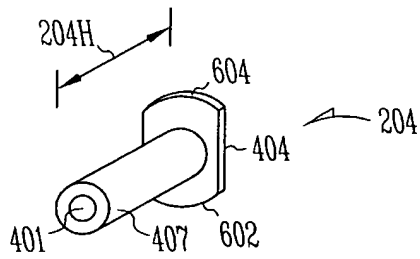


Fig.6

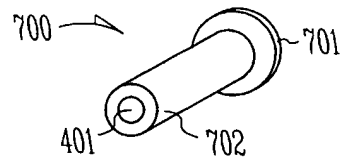


Fig.7

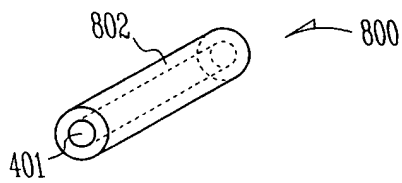


Fig.8A

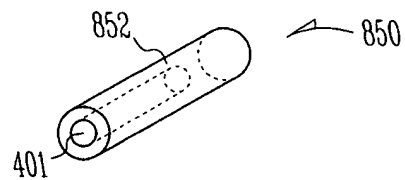


Fig.8B

TITLE: CAPACITOR HAVING A FEEDTHROUGH ASSEMBLY WITH A COUPLING MEMBER

INVENTORS NAME: Michael J. O'Phelan et al.

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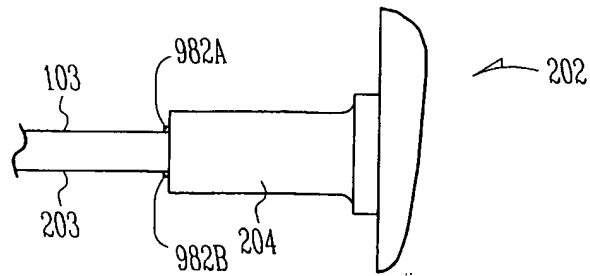


Fig.9

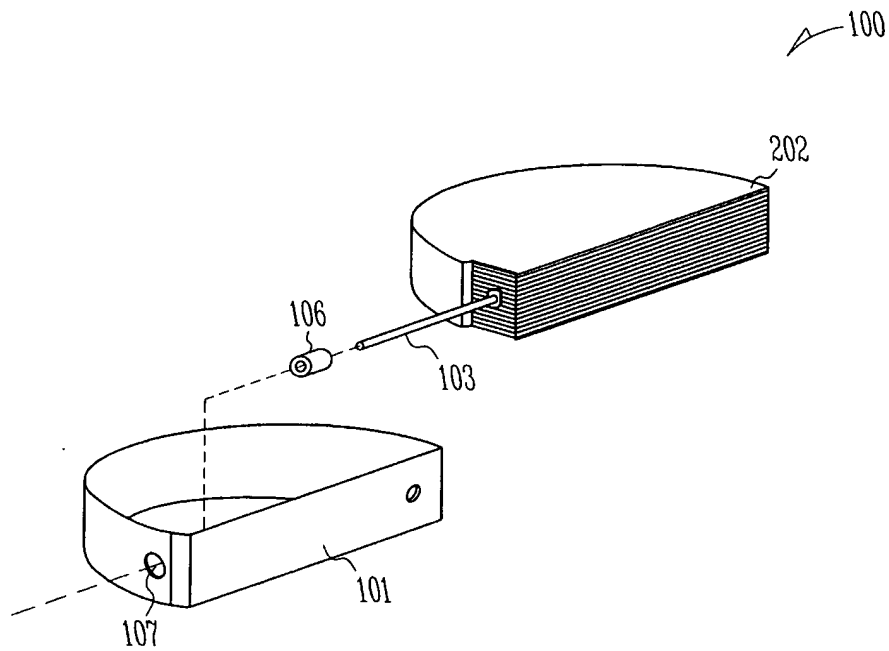


Fig.10

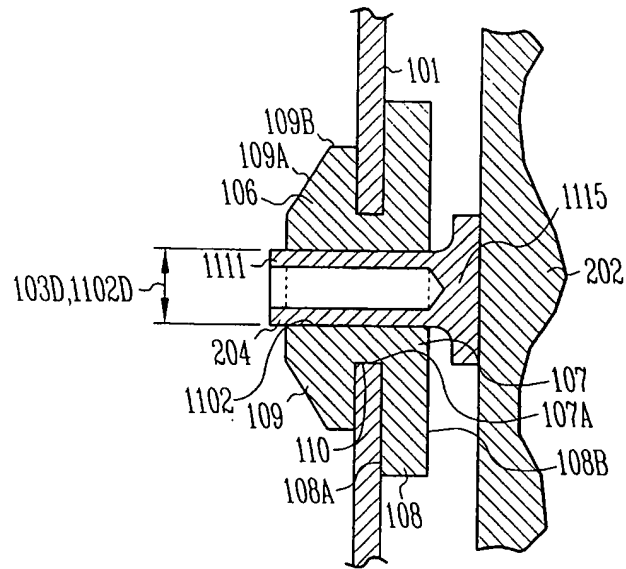


Fig.11

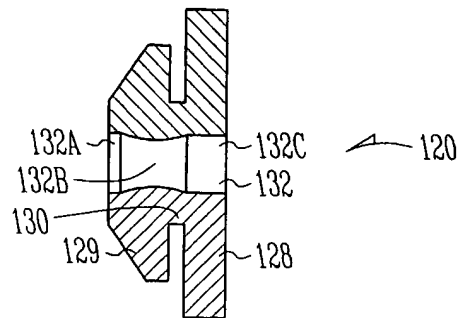


Fig.12

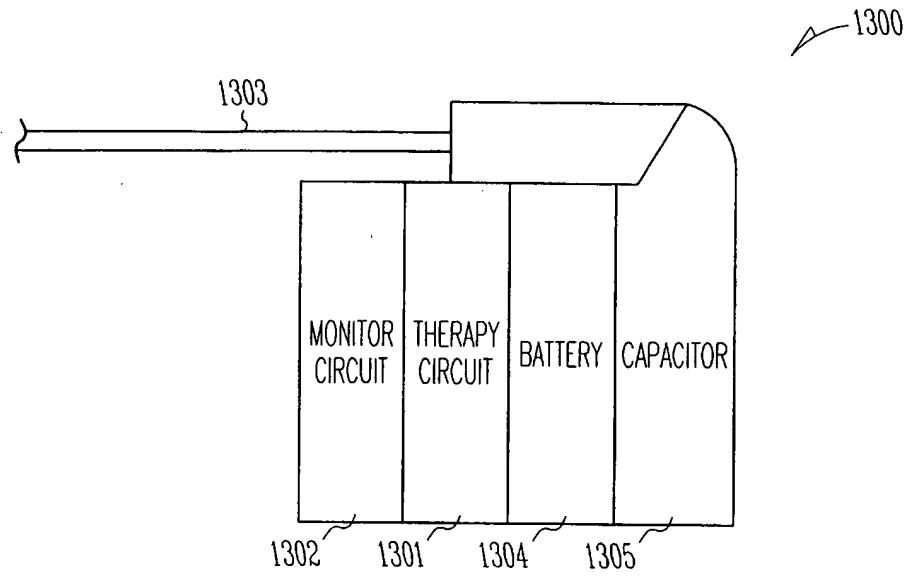


Fig.13